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THE MINERAL INDUSTRY OF THE BRITISH EMPIRE

AND

FOREIGN COUNTRIES.

WAR PERIOD.

CHROME ORE AND CHROMIUM.

(1913–1919.)

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GENERAL.

The ore of chromium is known under a variety of names, including chromite, chrome ore, chrome iron ore, and chromic iron ore. In the pure state chromite contains about 68 per cent. of chromic oxide and 32 per cent. of ferrous oxide. The ore of commerce, however, contains substantial amounts of magnesia, ferric oxide and alumina. Chromium ore is, indeed, considered of good merchantable quality if it contains, as it is usually required to contain in normal times, about 50 per cent. of chromic oxide. During the war the demand for chromium ore was so great that material ranging in composition down to 25 per cent. of chromic oxide found a market, and low-grade ore containing as little as 8 per cent. of chromite was concentrated and sold at a profit in Canada.

Chromite is usually found associated with serpentine, either in the form of bands or lenticular masses of fairly pure ore, or in the form of granules scattered through the mass of the serpentine. It is therefore to be sought for among very basic igneous intrusions in which olivine and chromite have segregated during the cooling of a basic magma. These basic intrusions have been metamorphosed in some cases, as at Selukwe in Rhodesia; and the serpentine with which chromite is usually associated has been formed by the hydration of olivine.

The following are representative analyses of chromium ore :—

—	Rhodesia ore as shipped.	New Caledonia high-grade ore.	Quebec Black Lake Concentrates.	Mysore ore as shipped.	Baluchistan high-grade ore.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Cr_2O_3 ...	42–51	54½	50½	51	56
FeO ...	18½	17½	18	22½	13
Al_2O_3 ...	14½–16½	11	10	7½	11
SiO_2 ...	4½	3	3	4½	1
MgO ...	8½–15	8	16	12	15
CaO ...	—	1½	2	½	1

The selling price of chromium ore depends on the percentage of chromic oxide present. In the British market the price is usually quoted per ton of ore. In America it is customary to quote the price in terms of cents per unit, the unit referred to being the unit percentage of chromic oxide (Cr_2O_3).

Chromium ore is utilized largely for making the alloy ferrochromium which enters into the composition of alloy steels used in the manufacture of armour plates, armour-piercing projectiles, guns, the jaws of rock-crushing machinery, and many other products. A steel containing about 12 per cent. of chromium has been used for many years for making wire draw plates. High speed steels contain from three to five per cent. of chromium, and the yearly consumption for this purpose in the

United Kingdom amounts to about 1,500 tons. A variety of chromium-iron alloy, containing from 12 to 15 per cent. of chromium is now used largely as a stainless and rustless steel capable of resisting attack by fruit acids, sea air and salt water. It is used in making cutlery, turbine blades, acid pumps, exhaust valves for aircraft engines, and in other ways; and is likely to be used more extensively in the future in the manufacture of machinery.

Another important alloy of chromium is stellite, which consists essentially of cobalt and chromium, usually with small amounts of various other metals, notably tungsten and molybdenum. Stellite is made into high-speed cutting tools, and on account of its resistance to nitric acid, it is serviceable in some measure as a platinum substitute.

According to information supplied to the Bureau by Dr. L. Aitchison, it is desirable that the ferro-chromium used in the manufacture of high-class steel containing a large proportion of chromium should contain as little carbon as possible and consequently the aluminium reduction of chromite is preferable to the carbon reduction. In the aluminium reduction, a great deal of the success of the operation, and the yield of ferro-chromium which is obtained, depends upon the proportion of magnesia. Very little trouble is experienced if the amount of magnesia is below 4 or 5 per cent., and there is a limited demand for ore of this quality at higher prices than those paid for ore richer in magnesia.

Chromite finds another important application in the manufacture of chromite bricks for metallurgical use as refractory material for lining furnaces. When used in this way a high degree of purity is less essential, since the serpentine (magnesium silicate) which is frequently present as a matrix of the chromite or scattered interstitially among the chromite grains, is itself fairly refractory and serves as a ready-made bond. It should be remarked, however, that high percentages of silica and iron oxide are not desired in chrome refractories.

A further important application of chromite is in the chemical trades for the manufacture of potassium and sodium chromates and bichromates, which are used in the tanning, dyeing and pigment, and other trades.

The relative amounts of chromium ore used for these different purposes is not the same in all countries, and is probably not the same in times of peace as in war times; but it is noteworthy that in the United States, which is a large consumer, the following was the War Trade Board's estimate of U.S.A. requirements for 1918.

For ferrochrome ...	52 per cent.	of total	consumption.
For chemicals ...	31 ,,	,,	,,
For refractories ...	17 ,,	,,	,,

WORLD'S PRODUCTION OF CHROMITE.

Previous to the war, Rhodesia and New Caledonia were for some years the chief producers of chromite. The contributions of these two countries were about equal, and together represented from 80 to 90 per cent. of the world's production. At that time India, Canada and the United States contributed comparatively small amounts to the output. Lack of ocean freight facilities during the war produced a great change. Large increases in the outputs of chromite in the United States, Canada and India constitute notable features of the production during the war years, as shown in the figures given below. In consequence of these conditions, there was a serious decline in the Rhodesian output during 1918.

The world's production for the period under review has been as follows :—

World's Production of Chromite *

(In metric tons (*a*).)

	1913.	1914.	1915.	1916.	1917.	1918	1919.
United Kingdom ...	113	119	—	392	303	—	—
Rhodesia	57,517	43,745	54,974	80,645	66,210	28,390	32,016
Canada	—	—	11,199	24,970	33,326	19,958	7,426
India	5,769	5,984	3,829	20,488	27,503	58,713	
Australia	688	660	769	621	1,365	730	†250
Bosnia and Herzegovina.	305	211	370	967	1,805		
Greece	6,342	7,059	10,420	9,880	6,750	10,890	
Norway	—	81	350	2,757	3,975		
United States ...	259	601	3,335	47,803	44,439	83,695	†3,964
Japan	1,332	2,117	2,991	8,283	8,947	7,244	
New Caledonia ...	63,370	71,708	57,474	57,024	41,892	26,000†	

BRITISH EMPIRE.

The effect of the war on chromium ore production in the British Empire is indicated by the fact that the Empire output grew from 50,508 metric tons in 1914 to 107,791 metric tons in 1918. For this increase in production India and Canada were chiefly responsible.

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* Other producing countries include Russia, Asia Minor, Brazil, Cuba, and Guatemala. No figures are available for Asia Minor from 1913 onward, but the annual production during the war period may be roughly estimated at from 15,000 to 20,000 tons.

(*a*) The metric, long and short tons referred to in this publication are equivalent to 2,204, 2,240, and 2,000 lb., respectively.

† Preliminary figures.

United Kingdom.†

During the period under review chromite was mined to a small extent from deposits in the Island of Unst, in the Shetlands. These deposits contain a large amount of low-grade chromite. The Unst chromite occurs in granules scattered through serpentine, which covers a large area in the island. The grade of ore is variable, but some of it is of fairly good quality. The quarries are thirty or more in number, but only six of these have been worked to any considerable extent. Most of the quarrying has been done in search of rich chromite, which occurs in irregular masses. Some of these, and specially that of the great Hagdale quarry, appear to have been of considerable size. The outputs for the United Kingdom given in the above production table represent shipments from Balta Sound between 1913 and 1917. The material was used in the manufacture of chromite bricks.

Four grades of ore were sold in 1916 and 1917, as follows :—

Grade.	Average percentage of chromic oxide.	Tonnage.
1. Best ore from various quarries	36·85	83
2. Hagdale quarry; dump ore, upper size from screen ...	31·68	232
3. Hagdale quarry; dump ore, under size from screen ...	27·33	233
4. Low-grade ore, various quarries and dumps... ...	23·34	147

The price paid in August, 1917, for ore delivered at Middlesbrough or Sunderland was 1s. 3d. per unit, plus 10s. per ton war bonus, plus 5s. per ton allowed for extra freight; so that ore containing 36 per cent. of chromic oxide was sold at Middlesbrough at the rate of £3 per ton, which was substantially below the price of imported ore.

The estimated working costs in Unst were as follows :—

	Per Ton. s.	Per Ton. d.
Quarrying costs...	8	0
Milling	4	0
Transport	1	0
General expenses	3	0
	16	0

---

† By arrangement with the Mineral Resources Development Branch of the Industries and Manufactures Department of the Board of Trade, these notes with reference to chromium ore in the United Kingdom have been abstracted from a report by Lt. Arthur Russell, who visited the Shetlands and reported on the chromite deposits for the Ministry of Munitions. The trade statistics are taken from the Annual Statement of the Trade of the United Kingdom.

The approximate costs per ton for conveying chromite concentrates from Balta Sound to Liverpool were as follows :—

	Per Ton. s.	d.
Bags	25	0
Loading	2	0
Sea freight to Sunderland	15	0
Dock charges at Sunderland	5	0
Rail charges, Sunderland to Garston...	11	3
Unloading charges and cartage at Garston	3	9
£3	2	0

It is noticeable that bagging, which was necessary for concentrates, was very expensive, and that for lump ore, which could be shipped without the use of bags, the transport charge would be £1 17s.

The exports of the chromates and bichromates of potassium and sodium from the United Kingdom during the period under review are remarkable as showing a large increase in the manufacture and exports of the sodium salts and decrease in the potash salts, as well as a large increase in value of the salts exported. The figures are as follows :—

United Kingdom Exports of Chromate and Bichromate of Potash.

Country to which exported.	Quantity (cwts.).						Value (£).					
	1913.	1914.	1915.	1916.	1917.	1918.	1913.	1914.	1915.	1916.	1917.	1918.
Egypt	(*a*)	(*a*)	1,450	1,337	3,407	3,186	(*a*)	(*a*)	4,918	11,012	27,303	35,524
Canada	1,731	755	670	288	158	139	2,551	1,125	2,100	1,914	1,196	1,599
British East Indies	2,544	1,117	4,563	2,408	3,786	587	3,739	1,773	13,569	15,426	31,609	6,414
Australia ...	1,810	2,075	474	51	134	73	2,591	3,044	1,302	454	904	876
Other British Possessions ...	284	221	314	472	259	322	425	371	1,002	3,187	1,936	3,387
Total to British Possessions ...	6,369	4,168	7,471	4,556	7,744	4,307	9,306	6,313	22,891	31,993	62,948	47,800
Belgium	3,814	706	—	—	—	—	6,258	1,066	—	—	—	—
France	10,575	7,293	1,057	81	1	8	14,951	10,565	2,945	568	11	123
Germany... ...	23,152	15,204	—	—	—	—	33,372	22,169	—	—	—	—
Netherlands ...	3,054	27	—	—	—	—	4,341	46	—	—	—	—
Sweden	1,849	986	—	—	—	—	2,798	1,486	—	—	—	—
Other Foreign Countries ...	7,033	7,333	165	86	33	19	10,430	11,117	560	1,077	297	186
Total to Foreign Countries ...	49,477	31,549	1,222	167	34	27	72,150	46,449	3,505	1,645	308	309
TOTAL ...	55,846	35,717	8,693	4,723	7,778	4,334	81,456	52,762	26,396	33,638	63,256	48,109

(*a*) Included with "Other Foreign Countries."

United Kingdom Exports of Chromate and Bichromate of Soda.

Country to which Exported.	Quantity (cwts.)						Value (£).					
	1913	1914	1915	1916	1917	1918	1913	1914	1915	1916	1917	1918
Canada	2,976	4,047	3,444	3,701	3,560	1,695	3,608	4,722	5,572	18,391	13,018	5,881
British India ...	(*a*)	2,075	10,045	8,601	16,753	7,518	(*a*)	2,697	15,156	34,459	68,179	32,840
Australia ...	214	1,715	6,725	7,903	6,692	6,199	293	2,207	11,018	32,817	26,120	31,905
Other British Possessions ...	602	491	656	1,094	1,582	434	853	667	1,101	7,067	6,880	2,171
Total to British Possessions ...	3,792	8,328	20,870	21,299	28,587	15,846	4,754	10,293	32,847	92,734	114,197	72,797
Belgium	1,367	814	—	—	—	—	1,989	1,087	—	—	—	—
France	12,634	20,929	53,085	60,060	62,731	53,960	15,221	26,068	75,589	168,450	168,642	150,502
Germany... ...	22,425	10,978	—	—	—	—	28,435	13,680	—	—	—	—
Italy	(*b*)	(*b*)	114	297	5,093	7,922	(*b*)	(*b*)	226	1,917	10,736	17,430
Netherlands ...	4,215	59	226	—	(*b*)	(*b*)	4,835	79	367	—	(*b*)	(*b*)
Spain	1,487	4,246	8,355	705	20	—	1,900	5,402	12,043	1,086	120	—
Switzerland ...	(*b*)	550	1,542	2,101	671	2,397	(*b*)	688	2,857	10,792	4,194	15,175
Other Foreign Countries ...	2,607	2,071	7,204	1,115	428	1,568	2,785	2,647	10,868	4,768	1,823	9,966
Total to Foreign Countries ...	44,735	39,647	70,526	64,278	68,943	65,847	55,165	49,651	101,950	187,013	185,515	193,073
TOTAL ...	48,527	47,975	91,396	85,577	97,530	81,693	59,919	59,944	134,797	279,747	299,712	265,870

(*a*) Included with "Other British Possessions."

(*b*) Included with "Other Foreign Countries."

Southern Rhodesia.*

The total output of chromium ore in Southern Rhodesia up to and including 1918 amounted to 581,558 short tons valued at £1,718,241. This total value exceeds that of any other mineral produced in Southern Rhodesia except gold.

Chromite is reported to occur at many localities in Rhodesia. Of these the best known are those of Selukwe, Makiro and Lomagundi, but productive mining has hitherto been confined to the Selukwe property, which has been worked since 1905.

The deposits at Selukwe consist of numerous lenticular masses of chromium ore in a matrix of talc-schist and serpentine. Some of the chromite lenses exceed 400 feet in length. The ore is won very cheaply by open-cast mining, and the cost of production is merely nominal, amounting only to a few shillings per ton. The ore as marketed contains from 42 to 51 per cent. of chromic oxide, 8 to 15 per cent. of magnesia, and 14½ to 16½ per cent. of alumina. The best ore contains on the average about 50 per cent. of chromic oxide. The material is sent by train to Beira and shipped to Europe as crude ore. Shipment was suspended for a time after the outbreak of the war in August, 1914, but was resumed in December, and the output for 1914 showed a substantial reduction compared with 1913. The output rose again in 1915, 1916 and 1917 in spite of the fact that exportation was hindered by lack of shipping facilities.

The price per short ton realised for the ore during 1917 was £4 9s. 7d., an increase of 14s. 7d. per ton as compared with the price during 1916. This increase in value stimulated prospecting, which resulted in the discovery of a large deposit in the Lomagundi district. Lack of shipping facilities, however, caused a serious fall in production during 1918, and the output for that year was confined entirely to the Selukwe mines.

Details of the production and export of chromium ore from Rhodesia are given in the following tables :—

Production of Chromium Ore in Southern Rhodesia.

Year.	Production.	Value.
	Short tons.	£
1913	63,384	141,481
1914	48,207	107 612
1915	60,581	175,792
1916	88.871	333,170
1917	72,963	327,347
1918	31,286	134,857
1919	35,282	142,541

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* Annual Report of the Rhodesia Chamber of Mines. Annual Report of the Secretary of Mines, Southern Rhodesia. Annual Statement of the Trade and Shipping of the Union of South Africa and of Southern and Northern Rhodesia.

Exports of Chromium Ore from Southern Rhodesia.

Country to which exported.	1913.	1914.	1915.	1916.	1917.	1918.
	Short tons.	Short tons.	Short tons.	Short tons.	Short tons.	Short tons.
United Kingdom ...	3,081	2,323	7,734	8,179	18,648	37,833
Northern Rhodesia ...	—	—	15	45	—	—
Union of South Africa	—	—	30	110	16	18
Belgium	3,829	2,085	—	—	—	—
Belgian Congo ...	—	—	—	—	1	—
France...	13,830	7,918	2,292	5,992	—	—
Germany	9,310	4,009	—	—	—	—
Holland	5,409	2,514	—	—	—	—
Norway	—	7,392	8,176	6,496	2,240	—
United States... ...	27,440	24,855	42,278	66,584	38,416	—
Total	62,899	51,096	60,525	87,406	59,321	37,851

Union of South Africa.*

There was no production of chromium ore in the Union of South Africa during the period under review, but many deposits are known, and some of these seem to be of prospective interest. Chromite is of very widespread occurrence around the margin of the Bushveld granite area in the Transvaal. The ore usually contains from 35 to 45 per cent. of chromic oxide.

At Jachtlust, a farm on the Oliphants River in the Lydenburg district, an extensive band of chrome ore about 6 feet wide is reported to occur. This farm is about 50 miles south-east of Pietersburg, and the proposed Middelburg-Pietersburg line of railway is expected to pass close by the property. The estimated costs of production of chrome ore at this property are as follows :—

	£	s.	d.
Mining	0	3	0
Hauling, loading, &c.	0	1	6
Transport to Pietersburg	0	15	0
Administration and white labour...	0	1	9
Total	1	1	3

Canada.†

The mining of chromium ore in Canada is confined chiefly to the Province of Quebec, where chromite is found in irregular deposits among the serpentine rocks in the Brome, Megantic,

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* Annual Report of the Government Mining Engineer for the Union of South Africa.

† Annual Report on the Mineral Production of Canada. Annual Report on Mining Operations in the Province of Quebec. Annual Report of the Minister of Mines, British Columbia. Annual Report on the Trade and Commerce of Canada.

Richmond and Wolfe counties. The output has been obtained chiefly from the deposits in the township of Coloraine, Megantic county.

For some time prior to the outbreak of the war the mining of chromium ore had been dormant in Quebec. In 1915, however, the demand for chromite led to active exploitation, and was so strong that a considerable amount of quite low-grade ore was produced, some of it containing not more than 20 per cent. of chromic oxide. At the end of the year purchasers refused material containing less than 25 per cent. of chromic oxide and the demand was as a rule for ore containing over 38 per cent. of the oxide.

During 1914 only chrome ore containing at least about 50 per cent. of chromic oxide was saleable on the American market and prices for 50 per cent. ore ranged from $14.50 to $15.50 per ton. Ore containing more than 50 per cent. of the oxide was purchased at the rate of from 50 to 60 cents per unit. Prices rose in the autumn of 1915 and the following were then the prices per long ton realised at the shipping station :—

Ore	containing	from	25	to	30	per cent.	Cr_2O_3	$14
,,	,,	,,	30	,,	35	,,	,,	16
,,	,,	,,	35	,,	40	,,	,,	18
,,	,,	,,	40	,,	45	,,	,,	20
,,	,,	,,	45	,,	50	,,	,,	25

The demand for Quebec ore in the United States continued for the rest of the war period as a result of the shipping difficulties which prevented the supply of ore in the quantities required from Southern Rhodesia and New Caledonia.

Prices rose still further, and in November, 1916, ore containing 25 per cent. of chromic oxide was quoted at $18 a long ton, f.o.b. Quebec central stations, while 50 per cent. ore realised $45 per long ton, and some special lots assaying over 50 per cent. were sold at the rate of one dollar per unit. Under these conditions it became possible to concentrate very low-grade ore. A Custom mill at Black Lake was operated for this purpose, and crude ore containing only about 12 per cent. of chromic oxide was concentrated to yield a 50 per cent. product. The mill had been in operation some years previously and had been closed down in 1909. It was repaired and refitted in 1916. It consisted of a Blake jaw crusher, which reduced the ore to 2-inch size, six batteries of 5 stamps each which reduced the ore to pass a 20-mesh screen, and seven Wilfley tables which treated the discharge from the stamps.

The tonnage of ore produced during 1918 was rather less than that during 1917 in spite of increasing prices ; and it is noteworthy that the output for 1918 included small shipments from Cascade, a few miles south-west of Rossland in British Columbia. During May and June, 1918, f.o.b. quotations reached $1.55 a unit for 45 per cent. ore, with variations of 5 cents per unit for grades above or below that standard, and it is recorded that 50 per cent. ore was sold in the United States at $100 per ton. The market for chromite ore collapsed after the armistice was signed, and at the end of the year only those operators were working who had contracts to fill at prices which made work possible without loss.

The Quebec authorities state that under the conditions obtaining early in 1919, a market price of 80 cents to $1.00 per unit for 45 per cent. ore was necessary to make mining profitable.

The Custom concentration mill at Black Lake operated throughout the year 1918, and the operating company bought ore containing as little as 8 per cent. of chromic oxide, at $2.10 per ton.

The average values of chromite per ton of ore shipped in recent years are reported to have been as follows :—1915, $14.55 ; 1916, $20.35 ; 1917, $24.5 ; 1918, $38.00.

The production of chromium ore in British Columbia in 1918 as reported by the Minister of Mines, British Columbia, amounted to about 800 tons. This output was obtained entirely from the Mastodon claim in the Cascade Section of the Grand Forks Mining Division. The total shipments amounted to 670 tons of ore containing on an average 38·5 per cent. of chromic oxide. The occurrence at the Mastodon claim has been known for some years but it was not developed until 1917, when by stripping and sinking shallow shafts some small lenses of chromite were uncovered. The chromite had to be hauled by teams to the Canadian Pacific Railway at Cascade, a distance of 8 miles, and was shipped to the Central States. The haulage costs were $7 per ton, railway freight approximately $17 per ton, and excavation costs $4.25 per ton. The amount of development work hitherto done has not proved conclusively the extent of the ore-bodies, but so far as it has gone it indicates that the lenses have a north-westerly strike and that they dip almost vertically. They have an average width of about 6 feet at the thickest part, vary in length from 10 to 20 feet and have a height of about 10 feet. They are favourably situated as regards railway transportation and electric power, and it is thought that, should the demand for chromite again arise, the cost of mining these deposits could be much reduced by the construction of an aerial tramway from the claims to the railroad.

Production of Chromium Ore in Canada.

—	1915.		1916.		1917.		1918.		1919.	
	Quantity. Short tons.	Value. $	Quantity. Short tons.	Value. $	Quantity. Short tons.	Value. $	Quantity. Short tons.	Value. $	Quantity. Short tons.	Value. $
Production (shipments) :—										
Crude ore	12,341	179,543	14,249	266,217	20,153	441,540	15,605	456,408		
Concentrates	—	—	1,000	44,685	3,558	140,256	6,389	410,714		
	12,341	179,543	*15,249	310,902	*23,711	581,796	21,994	867,122		
Production :—										
Quebec	12,341	179,543	27,517	311,460	36,725	499,682	21,324	835,727		
British Columbia ...	—	—	—	—	—	—	670	31,395		
Exports (to the U.S.A.) ...	7,290	81,838	12,633	152,534	19,229	342,528	15,831	353,616		
Imports :—										
Bichromate of soda ...	234	34,692	711	362,571	667	248,621	523	208,669		
" " potash ...	71·0	17,413	15·5	13,381	10·1	6,697	10·4	10,686		

* Shipments as reported directly by operators in 1916 were 27,517 tons valued at $311,460, and in 1917, 36,725 tons valued at $499,682.

Imports of Bichromate of Potash into Canada. (Fiscal years ending March 31.)

From.	Quantity (cwts.).							Value.$						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	2,593	2,442	641	1,085	259	35		19,329	17,934	5,128	15,994	12,490	1,226	
Belgium ...	261	—	—	—	—	—		2,207	—	—	—	—	—	
Germany ...	527	108	—	—	—	—		4,012	808	—	—	—	—	
Netherlands ...	—	14	—	—	—	—		—	111	—	—	—	—	
United States...	108	185	276	56	77	26		901	1,495	3,480	1,029	3,287	1,182	
Total from Foreign Countries	896	307	276	56	77	26		7,120	2,414	3,480	1,029	3,287	1,182	
TOTAL ...	3,489	2,749	917	1,141	336	61		26,449	20,348	8,608	17,023	15,777	2,408	

Canadian Imports of Bichromate of Soda. (Fiscal years ending March 31.)

FROM.	Quantity (cwts.).							Value $.						
	1913	1914	1915	1916	1917	1918	1919	1913	1914	1915	1916	1917	1918	1919
United Kingdom	2,944	3,234	4,082	2,794	3,712	2,926		19,170	19,662	21,628	32,434	115,041	68,796	
Belgium ...	46	—	—	—	—	—		316	—	—	—	—	—	
France	—	40	—	—	—	—		—	275	—	—	—	—	
Germany ...	702	371	210	—	—	—		4,917	2,373	1,187	—	—	—	
United States ...	1,363	2,232	1,068	4,612	7,413	7,435		8,208	10,483	6,192	73,204	221,989	146,373	
Total from Foreign Countries	2,111	2,643	1,278	4,612	7,413	7,435		13,441	13,131	7,379	73,204	221,989	146,373	
TOTAL ...	5,055	5,877	5,360	7,406	11,125	10,361		32,611	32,793	29,007	105,638	337,030	215,169	

India.*

The chromite-producing areas of India, in order of importance, are Baluchistan, Mysore, and Bihar and Orissa. The production during the period under review, as recorded in the Annual Reports on Mineral Production in the Records of the Geological Survey of India, has been as follows :—

Province.	Quantity (long tons).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Baluchistan ...	3,414	3,006	2,161	7,620	15,659	22,944	
Mysore	1,414	2,330	1,041	9,802	8,136	33,740	
Bihar and Orissa (Singhbhum).	848	552	565	2,737	3,266	1,085	
Total	5,676	5,888	3,767	20,159	27,061	57,769	

Province.	Value (£).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Baluchistan ...	1,162	1,052	2,161	7,620	15,659	22,944	
Mysore	821	1,258	1,088	6,286	7,446	27,474	
Bihar and Orissa (Singhbhum).	452	301	282	2,495	3,111	1,644	
Total	2,435	2,611	3,531	16,401	26,216	52,062	

Chromite in Baluchistan exists as veins and segregations in serpentine associated with Upper Cretaceous igneous intrusions. The deposits are distributed along the hills bordering the Zhob valley and the upper part of the Pishin river. One mass of almost pure ore, measuring 400 feet by 5 feet and containing over 54 per cent. of chromic oxide was found about 2 miles east of Khanozai (30°37′ : 67°20′). The Baluchistan ore is of high grade, and was in considerable demand during the war.

During the greater part of the period under review, chromite mining in Mysore was restricted to the districts of Mysore and Hassan, the most important deposits being those near the village of Kadakola in the Mysore district. The chromite at this locality is associated with serpentinized saxonite and occurs mostly as a narrow vein averaging not more than a foot in thickness; but at one place it swells out to form a large lens. The ore is of fairly good quality yielding up to 52 per cent. of chromic oxide, but much of it is probably of low grade. In the Hassan district the chromium ore is in the form of grains embedded in a talcose matrix and the better portions of the rock probably contain 30 to 40 per cent. of chromic oxide.

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* Records of the Geological Survey of India.

The ore worked in the Singhbhum district of Bihar and Orissa is found as bed-like veins and scattered granules in serpentine. The layers of chromite vary from an inch to a foot in thickness, and are very irregular both in size and distribution, though they yield ore of fairly good quality, containing about 50 per cent. of chromic oxide. It has been found that ore lying at a greater depth than 35 feet below the surface cannot be profitably worked as the ore-bodies are too small to repay the cost of exploitation. Prospecting was carried on vigorously in the Singhbhum district during 1916 and 1917 and the results are reflected in the noticeable increase in production for those years, though the output fell substantially in 1918.

In spite of the fact that the chromite mines of India are remote from the sea-board and not easily accessible, they have shown a remarkable activity during the war, due to the high prices that have been obtained for the ore. A noteworthy feature shown by the output figures is the substantial increase in the Mysore production. This is attributed to the rapid development of a recently discovered property at Bairapur from which a large proportion of the 1918 output was obtained.

It is reported that about 30,000 tons of ore, averaging about 50 per cent. of chromic oxide, was produced from the Bairapur mine during 1918 and the early part of 1919, under a mining licence which expired in March, 1919. The following analysis represents the composition of a shipment of 1,200 tons of Bairapur chromium ore:—Cr_2O_3, 51·10; FeO, 21·44; Fe_2O_3, 1·03; Al_2O_3, 7·60; CaO, 0·60; MgO, 12·13; MnO, 0·30; SiO_2, 4·50; SO_3, 0·05; combined water, &c., 1·30. A representative sample from a shipment of 10,000 tons of ore yielded about 50 per cent. of chromic oxide.

The exports of chromium ore from India for the fiscal years ending March 31 have been as follows:—

Exports of Chromium Ore from India.

To.	Quantity (Long Tons).						Value (£).					
	1914.	1915.	1916.	1917.	1918.	1919.	1914.	1915.	1916.	1917.	1918.	1919.
United Kingdom	1,701	3,167	1,596	6,094	12,229		4,109	10,766	4,422	10,278	24,986	
France	1,897	487	250	—	—		5,096	1,623	500	—	—	
Italy	—	—	—	—	2,191		—	—	—	—	4,882	
Japan	—	10	—	96	555		—	15	—	195	2,849	
Total Foreign Countries ...	1,897	497	250	96	2,746		5,096	1,638	500	195	7,731	
TOTAL ...	3,598	3,664	1,846	6,190	14,975		9,205	12,404	4,922	10,473	32,717	

The imports of sodium and potassium bichromate into India during recent years have been as follows* :—

	Sodium bichromate.		Potassium bichromate	
	Quantity long tons.	Value £	Quantity long tons.	Value £
1914–15	187†	5,574	103*	4,996
1915–16	352	13,732	163	11,882
1916–17	449†	44,923	65*	11,120
1917–18	820†	75,179	253*	54,328

† Except Bengal.

The Director of Industries, United Provinces, stated in his report for 1916-17 that the commercial manufacture of bichromate of potash had been successfully established, and that local supplies had been of great value to the various industries. A company has recently been formed in Calcutta for the purpose of manufacturing chromium salts.

Australia.‡

Chromite is found at numerous localities in Australia, but, as shown in the world's production table above, only a comparatively small amount of the ore was obtained during the period under review. The output was irregular and was restricted to the States of New South Wales and Queensland, the production being as follows :—

Production of Chromium Ore in Australia.

Year.	New South Wales.		Queensland.		Commonwealth.	
	Quantity (long tons).	Value (£).	Quantity (long tons).	Value. (£).	Quantity (long tons).	Value. (£).
1913	500	500	177	177	677	677
1914	649	649	—	—	649	649
1915	638	1,600	119	—	757	
1916	450	203	161	—	611	
1917	587	1,468	756	756	1,343	2,224
1918	368	911	350	350	718	1,261
1919	250					

Six mines contributed to the New South Wales output of chromite during 1917.

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* Indian Munitions Board Industrial Handbook, 1919.

‡ Annual Reports of the Department of Mines, New South Wales. Annual Reports of the Under Secretary for Mines, Queensland.

In Queensland, the output during 1912 and 1913 was from the Elgalla mine near Cawarral, and in the latter year it was sent to the Mount Morgan Co. Of the 1918 output 185 tons were sent to Cloncurry, Mount Lyell and elsewhere.

Australia was threatened with a shortage of ferro-alloys during the war, and in consequence of this threatened shortage the Advisory Council of Science and Industry, at the suggestion of the Federal Munitions Committee, carried out some experimental work on the manufacture of ferro-alloys, including ferro-chromium, in the Metallurgical Department of the University of Melbourne. The experiments were made with an electric furnace of the Heroult type. Chromium ore from Noumea in New Caledonia was used, as no supplies of Australian ore were available at the time. The ore had the following composition :—Cr_20_3 51·72, FeO 14·70, MgO 14·18, $A1_2O_3$ 17·90, and SiO_2 0·83 per cent. No anthracite could be obtained and coke containing 85·53 per cent. of fixed carbon was used as a reducing agent in the experiments that were made. It was found as a result of these experiments that the manufacture of ferro-chromium presented no special difficulties. The cost of production of the crude alloy was about 1*s*. per lb., and that of refining was about 5¼*d*. per lb., not reckoning labour. Current was paid for at the rate of 1¾*d*. per unit, but if used in large quantities it could have been obtained at ½*d*. per unit.

FOREIGN COUNTRIES.

Before the war, as already pointed out, New Caledonia was the only foreign country which had a chromium ore output comparable with that of Rhodesia; but Greece, Russia, and Turkey produced considerable amounts, whilst the outputs of Japan and the United States were small. Lack of freight facilities during the war revolutionized this order of things as is seen from the outputs for 1916, 1917 and 1918, which show that the United States became the leading factor in the world's production of chromite during the last year of the war.

Greece.

Chromite in Greece occurs chiefly in the eastern provinces and in the island of Skyros. It is mined in the districts of Pharsala, Nezero and Archani. The ore contains on the average between 34 and 42 per cent. of chromic oxide and from 3 to 5 per cent. of silica. It is serviceable as a refractory.

The production and sales have been as follows during the years 1913-1919 :—*

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* Tableaux Statistiques du mouvement minier de la Grèce.

Year.	Production (metric tons).	Sales.	
		Quantity (metric tons).	Value (£).†
1913	6,342	6,930	11,925
1914	7,059	9,380	15,952
1915	10,420	7,520	16,411
1916	9,880	10,447	35,656
1917	6,750	9,600	58,710
1918	10,890	4,420	29,752
1919			

† Converted at the rate of 25 francs = £1.

Serbia.

Chromium ore is reported to have been mined by Germans during 1918 at Gorantza and Grechane; and chrome mines at Uskub in the Vardar valley are reported to have been worked by Bulgarians.

Brazil.

Chrome ore deposits of some importance near Queimadus and Bom-Fim in the State of Bahia were developed during 1918. The particular masses of ore then being worked were expected to yield from 20,000 to 25,000 tons. The ore produced contained from 44 to 46 per cent. of chromic oxide and was shipped to Philadelphia.

Cuba.

Important chromite deposits are reported by the United States Geological Survey to occur in northern Cuba, mostly within 10 miles of the coast. They are of the ordinary type with a matrix of serpentine. The reserves of marketable ore are estimated to range from 92,500 to 170,000 long tons, but it was estimated that probably only about 2,000 tons would be shipped in 1918.

Guatemala.

Chromite deposits were discovered and exploited during the war in Guatemala. An output of 2,504 tons is reported for 1917, chiefly at the " Mina Corona " in the Jalapa district.

United States.*

The United States felt more than any other country the serious effect of the war on chromite supplies. Before the war the importation of chromium ore from Rhodesia and New Caledonia was more economical than its production from the deposits in California and other western States, which are widely separated from the centres of the steel industry. The shortage of supplies from Rhodesia and New Caledonia, however, led to a large increase in value, and stimulated production in the west. In the year 1914 the United States consumed 81,327 long tons of chromium ore valued at $704,360 made up of 591 tons of domestic ore and 80,736 tons imported. In the year 1918 it consumed 182,574 long tons valued at $6,830,816, made up of 82,350 tons of domestic ore and 100,224 tons imported, chiefly from Canada, Rhodesia, New Caledonia and Brazil.

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* Mineral Resources of the United States (Annual). Annual Report on the Foreign Commerce and Navigation of the United States.

Of the total output during 1918 in the United States, California produced 56,200 and Oregon 22,500 long tons. The comparatively small remainder was produced in Maryland, North Carolina, Pennsylvania, Washington and Wyoming.

When the war came to an end production fell to a comparatively insignificant amount, as the cost of domestic ore was substantially in excess of imported ore, and production in a large way in the western States had depended entirely on the abnormal demand and consequent high prices brought about by the war.

As regards the quality of the ore mined and sold in the United States during 1917 it is reported that :—

10 per cent. contained from 30 to 38 per cent. of chromic oxide.
36 ,, ,, ,, 38 ,, 41 ,, ,, ,,
32 ,, ,, ,, 41 ,, 45 ,, ,, ,,
22 ,, ,, ,, 45 ,, 50 ,, ,, ,,

The ore is consumed in the United States chiefly for the manufacture of ferro-chrome, which is required largely for the manufacture of high-speed steels; but large quantities are used also in the chemical trades, and for making the chromite refractories used extensively in metallurgical industries. The estimated relative amounts of chromium ore required for these different purposes during 1918 have been already mentioned (p. 5).

The imports of chromium ore and chromium compounds into the United States are shown in the two following tables :—

Imports of Chromium Ore into the United States.
(In long tons.)

Country from which imported.	1913.	1914.	1915.	1916.	1917.	1918.
Cuba...	—	—	—	34	17	8,821
Brazil	—	—	—	—	—	17,854
Canada	—	533	10,087	12,220	19,012	20,949
Australasia	—	—	—	—	—	17,039
England	—	58	2	5	5	4
Greece	4,600	8,155	4,305	7,900	—	—
Japan	79	—	—	—	—	—
French Oceania ...	21,850	30,860	28,021	33,936	—	25,761
British S. Africa ...	30,001	23,200	34,030	61,850	42,550	8,521
Turkey in Asia ...	8,650	11,880	—	—	—	—
Guatemala	—	—	—	—	179	1,193
Total... ...	65,180	74,686	76,455	115,945	72,063	100,142

Imports of Chromium Compounds to the United States.

—	Quantity (cwts.).							Value ($).						
	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Chromic acid ...	50	82	32	—	—	85		1,100	1,597	755	—	—	1,857	
Chromate and bichromate of potash.	166	284	294	4	21	·2		1,819	2,375	2,902	75	962	8	
Chrome or chromium and ferrochrome or ferrochromium.	6,140	4,000	640	200	—	—		51,415	21,553	1,662	1,998	—	—	
Chromate and bichromate of soda.	·08*	99*	—	55	197	46		3*	542*	—	3,630	4,075	1,184	

* For year ending June 30th.

Asia Minor.

Chromium ore of good quality occurs in various parts of Asia Minor, notably in the Brusa district. The Dagh Ardi mines in this district are reported to have yielded about 15,000 tons a year during the war. The ore is of good quality and contains about 50 per cent. of chromic oxide. The workings are in part underground, and there is an elaborate ore-dressing plant, including up-to-date screens, classifiers, jigs and Wilfley tables. The mines were worked during the war to supply German requirements.

Other localities in the Brusa district from which chrome ore was obtained during the war were Miram, Kosludja, Artranlar, and Kaliar; but a total of only 900 tons is reported as having been shipped from these localities though 16,500 tons were stacked and could not be shipped as there were no facilities for transport.

New Caledonia.

Chromium ore occurs abundantly in New Caledonia partly in the form of veins and irregular masses in serpentine and partly in the form of friable lumps embedded in ferruginous clay. The latter variety is easily worked and is much sought for not only on this account, but also because it is a high-grade ore. The most important deposits are those in the vicinity of the Tiebaghi mine where the chromite occurs in decomposed serpentine and has been concentrated near the surface by weathering agencies. The Tiebaghi mine is within a few miles of the sea on the northern side of the island. Modern methods of mining, transport and loading are adopted in New Caledonia, and early during the war period furnaces were built at Noumea and Thio. There are hydro-electric plants at Tate and Tao, which have been built for the purpose of manufacturing ferro-chromium and ferro-nickel.

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